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QC (Quality Control) for Stationary Source Particle Size Measurements

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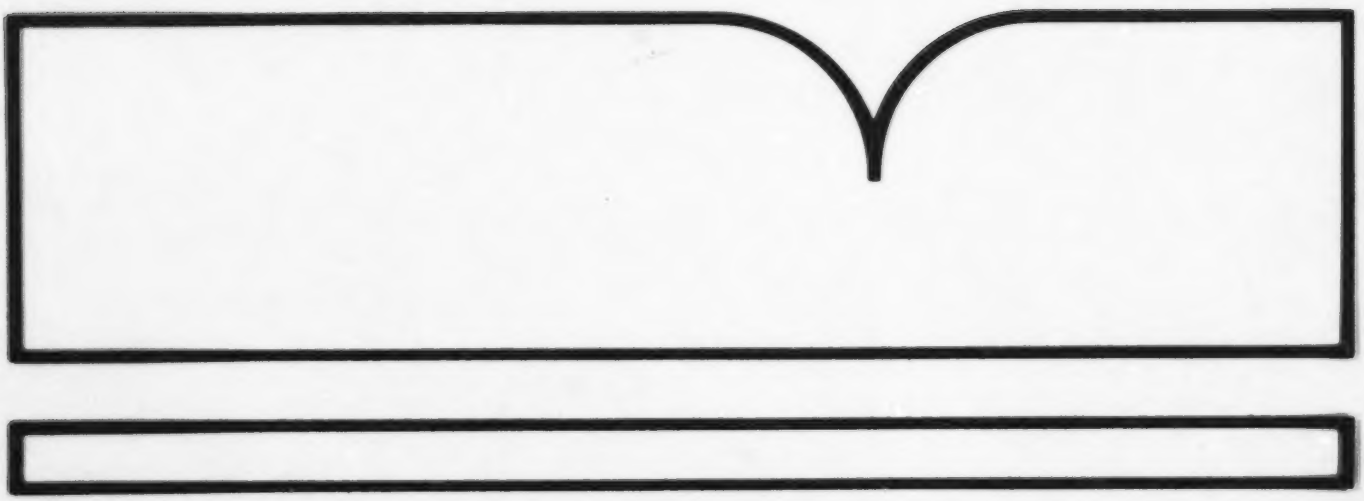

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QC for Stationary Source Particle Size Measurements

by

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16. ABSTRACT The paper discusses quality control (QC) for stationary source particle size measurements. Traditional QC methodology has generally involved retrospective evaluation of existing products (e.g., environmental data). Rather than identify failures, it is now increasingly possible and desirable to provide increased QC support to the production of data; i.e., doing it right the first time. It is clear from many disciplines that timely feedback mechanisms are one of the easiest, least expensive means of providing this support. In addition to some of the considerations related to source emissions testing, these concepts have been applied to cascade impactor testing. The Particle Data Reduction (PADRE) system offers a standard, quality assured data reduction method and protocol for particle size testing of stationary point sources using cascade impactors. The utilization of PADRE in testing has, to date, produced improved quality assurance documentation and greater confidence in the quality and credibility of the measurements data obtained.

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QC FOR STATIONARY SOURCE PARTICLE SIZE MEASUREMENTS

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As published in a recent Federal Register, the development of size-based standards for ambient particulate matter is in process. The most readily controlled pollutants are of anthropogenic origin. Thus, it may be expected that New Source Performance Standards (NSPSs), Prevention of Significant Deterioration (PSD) standards, and State Implementation Plan (SIPs) will require modification to include concentration measurements as a function of particle size should final approval of the proposed Ambient Air Quality Standard be obtained. Cascade impactors integrate readily into the standard scheme for source sampling and analysis, and are commonly used for making such measurements. Since impactor sampling and data analysis are more complex than for total particulate mass (e.g., EPA Method 5), the U. S. Environmental Protection Agency is providing technical support for improved impactor operation and data analysis. The Particle Data Reduction (PADRE) system for interactively computing, managing, and evaluating impactor data during field operations is described as an example standard operating procedure for data reduction and analysis, and whose use will provide the test crew with an additional quality control tool in measurements work.

QC FOR STATIONARY SOURCE PARTICLE SIZE MEASUREMENTS

BACKGROUND

The current ambient air quality standard for particulate air pollution is based on the mass concentration of total airborne particulate matter without regard to its size distribution. This definition permits development of the required information using straightforward measurement of a few, readily available, observable data. The smaller the particle, the relatively greater potential it has for surface interaction, since, for a specified mass, there is a greater number of particles as well as a larger total surface area. Development of the proposed PM-10 regulations is based primarily on recognition of this awareness.[1] However, the difficulty and cost of controlling airborne particles are also size-dependent, being roughly proportional to specific surface area and potential adverse health effects. The highest quality data are thus required in order to satisfy the competing needs for healthful, yet economic, particulate control.

Although the new regulations directly address ambient air, they will also induce effects in many related programs, such as SIPs and NSPSs. Total mass concentration data (e.g., data from hi-vol samplers and Method 5) are presently available through these programs. However, reliable means for relating total mass to size distribution (see Figure 1) have not yet been developed. In addition, it is to be anticipated that future strategies may call for the ability to characterize the particle-size distribution at additional points over the range of 0.1 to 20 micrometers.

From the perspective of pollution control, the characterization of stationary source particulate emissions by size is an important consideration, since control device efficiency may be strongly affected by particle size. While other particle size measurement methods are available, cascade impactors have been the most commonly used method of particle measurement. They classify particles on the basis of aerodynamic diameter; the measurement principle is inertial impaction, which is analogous to the deposition mechanism in the head and lung.[2] The experimental methods are similar to the existing EPA Method 5 for particulate total mass.

The focus of this presentation is the production of quality assured information from the aggregate raw data, particularly in a manner that provides timely feedback to the test crew during a test. The Particle Data Reduction System (PADRE) will be discussed as an example application of these concepts.

THE PRACTICAL PROBLEM

Source testing as a means of collecting meaningful scientific data can only be described as difficult. The experiment is frequently susceptible to perturbations that may adversely affect the character of the data collected.[3] In particular, cascade impactor measurements are highly sensitive to outside effects, which may have dramatic implications for the quality of the data collected. For example, cascade impactor measurements require care to ensure that impactor flow rates remain constant during changes in the source and in

the sampling train. Preparation and disassembly of the impactor requires care, commensurate with desired weighing accuracy of a fraction of a milligram substrates, in quite variable laboratory environments.

The logistics of cascade impactor preparation, operation, and cleanup usually impose a minimum of 12 hours for obtaining results from an experiment. Stage catches and cutpoints depend on sampling train operation, so the immediate results do not allow comparison from one run to the next. Final results are often unavailable until several weeks after the conclusion of the test, which precludes any changes to the test procedures as a result of problems encountered during actual test performance. Finally, costs of $100 or more per person, plus transportation and setup time, discourage keeping the test crew on-site while preliminary results are obtained and evaluated. Unfortunately, one finds that the data may be of such poor quality as to be unusable for their intended purpose and there is no opportunity for more testing.

QA/QC FOR IMPACTOR MEASUREMENTS

Quality assurance and quality control for environmental measurements have been frequently reviewed from the perspective of an audit function. For example, calibrated orifices are available to audit dry gas meter volume measurements. The quality of pitot tubes and sampling nozzles may be checked visually and by using calipers. Qualitative audits address total system operation, including equipment and personnel, the sampling train, and the data handling system. Each of these is essentially an after-the-fact audit and cannot discover invalid data on a "real-time" or near "real-time" basis.

Current philosophy regarding QA/QC suggests that problem prevention is a better approach than problem correction. In this context, it seems wise to encourage the collection of valid, environmentally related data by a variety of means. For example, suitable training and continuing education of test crews is one investment. Equipment calibration and maintenance on a regular, logical basis is required by EPA's QA policy.[4] Appropriate support facilities for equipment assembly and disassembly, weighings, etc., as well as scheduling for adequate equipment turn-around time, all contribute to encouraging the collection of valid data of specified quality.

CLOSING THE LOOP

An aspect of QA/QC, which is quite important, but is frequently overlooked, is that of providing timely feedback to the test crew (see Figure 2). The key element here is that the test crew makes the observations that relate the physical world with the abstract data from which information is generated. Additionally, they are able to assimilate information about the totality of a test (e.g., source operating variations, interpretation of information, peculiarities encountered), which can be utilized to adjust the test plan, and thereby enhance the quality and credibility of the collected data and their interpretation. The key is to INFORM the test crew members adequately and rapidly of the purpose of the test and of the progress of the data collection effort.

Recent developments in computer technologies offer potential capabilities for data collection and information generation, which were unavailable even a few months ago. This involves not only the speed of information production, but the complexity and format of the information presentation itself. However, to take even partial advantage of this potential requires a fresh look at the overall sampling, analysis, and data acquisition and handling systems.

CONSIDERATIONS

In developing the data handling system, which includes both the hardware and software, several aspects need to be considered if this resource is to be effectively used. A primary consideration is that all required inputs (Figure 2,i) be as simple and logical as possible. For example, each data item must be entered only once, exactly as it is observed. This means that the individual impactor substrate preweights and post-weights are entered and stored by the computer -- not the net weights. The net weights are computed from this observed data. If thermometers are marked in degrees Fahrenheit, then data are entered and verified in those units (the software will quickly and accurately make the desired conversion to Celsius or Kelvin). This also suggests that the input be organized to accept data in the normal testing event sequence. For example, allow entry of run data independently of weight data and independently of gas analysis data in order to coordinate efforts with various data sheets.

The corresponding consideration is that outputs (Figure 2,iii) be tailored to fit their intended use. Frequently, programming is easier (and cheaper) if the computer information is only in tubular form. Yet, it is clear that the computer more quickly and accurately rearranges the data into, say, graphic information for comparison, than can a test crew member. In addition, the same data entered and used in the field can be used to generate tables for inclusion in a final report, with assurance that the transmitted information accurately reflects the observations of the test crew. Additionally, if the data are stored and processed at a central computer site, then both the field crew and project team members from the home office can have equal access to the data for review and evaluation; this enhances the technical capabilities of the field crew.

From a data quality perspective, such capabilities offer significant potential. Data entry (Figure 2,i) can be checked in several ways. For example, simply printing the data in a standard format after their entry will permit independent checking of digit transposition and exponent errors. Range-checking of the data by the systems is possible, based either on the experience of the progamming staff with the field situation, or as data from the specific test accumulate sufficiently for developing statistical tests for each data item. It is also just as feasible to do inter-variable testing (Figure 2,ii), such as jet velocity and Reynolds number checks for impactor data. Such derived data can provide checks on typographical mistakes as well as feedback to the sampling crew relating to the actual operation of the sampling train. These checks can now be performed in a very few seconds. There are virtually no limits on the degree of "user friendliness" that can be achieved between the user and the computer.

EXAMPLE: PADRE

As an example of this approach to QA, EPA's Air and Energy Engineering Research Laboratory at Research Triangle Park, North Carolina (AEERL) developed the Particulate Data Reduction (PADRE) system in support of data reduction for cascade impactor measurements.[5] While this application is specific to one measurement technique, it illustrates the major QA/QC concepts discussed above. PADRE was designed from the outset to be a centrally supported and maintained system with a common computer code available to impactor users throughout the country. It is a user-friendly interactive program with extensive QA/QC checks at various levels of complexity and has been developed specifically to be compatible with expected PM-10 test protocol. For example, to enter character data, when numeric data have been requested, is acceptable. Also, when the stored data would result in a system abort -- say, when negative net weights are encountered -- data reduction calculations are not performed and the user is told why. However, when procedural errors -- such as high jet velocities or short sampling times -- are detected, data reduction is permitted, and the user is warned of the possible error condition. Extensive editing and review are permitted to allow the user as much control of the situation as possible. Once a user has satisfied the extensive security checks of the computer center and PADRE, he/she has full editing control of his/her own data. However, to avert possible accidents, user cannot delete data.

The information, which may be generated directly using PADRE, is varied and is selectable by the user. For example, data for an impactor run may be printed in detail with the commonly used concentration calculations for each impactor stage (Figure 3). In this case, the data are also interpolated to estimate the concentration values at a set of 11 standard particle diameters from 0.1 to 20 micrometers. This is done to facilitate manual comparison of related impactor runs. Data for runs selected from a given test may be compared on the basis of cumulative or derivative sizedistributions, and minimum, maximum, mean and standard deviation values at the standard diameters. Scatterplots of cumulative distributions are also selectable. Where data at the inlet and outlet of a control device are stored, efficiency (and penetration) calculations are also selectable by the user. As noted previously, these data may be presented to the test crew while they are still at the site as well as by other personnel offsite.

In addition, users have the option of printing the impactor data in a form suitable for inclusion in the final report, and for printing for the forms for submitting the data for entry to the Environmental Assessment Data System's Fine Particle Emissions Information System (EADS/FPEIS), also supported by AEERL.[6] In all cases, information is produced as needed, directly from the stored, observed data. Thus, a means is provided for satisfying potential PM-10 measurement requirements for stationary point sources beginning with field evaluation of data through archival of the evaluated data in the EADS/FPEIS.

FUTURE

Work on PADRE was begun before the availability of truly portable computers and displays. Processing and display power has increased significantly in recent months. With this in mind, possibilities are being explored for upgrading PADRE for video screen and menu selection operation, with significantly enhanced high resolution graphics capabilities. Also EPA's interim microcomputer standardization presents the potential for offering centrally maintained, downloadable, executable codes from a central computer to a portable microcomputer. This would offer the advantage of centralized, long-term software maintenance with the local processing advantages of a portable microcomputer.

SUMMARY

Traditional quality assurance methodology has generally involved retrospective evaluation of existing products (e.g., environmental data). Rather than identify failures, it is now increasingly possible and desirable to provide increased quality control support to the production of data; that is, doing it right the first time. It is clear from many disciplines that timely feedback mechanisms are one of the easiest, least expensive means of providing this support. In addition to some of the considerations related to source emissions testing, these concepts have been applied to cascade impactor testing. The PADRE system offers a standard, quality assured data reduction method and protocol for particle size testing of stationary point sources using cascade impactors. The utilization of PADRE in testing has, to date, produced improved quality assurance documentation and greater confidence in the quality and credibility of the measurements data obtained.

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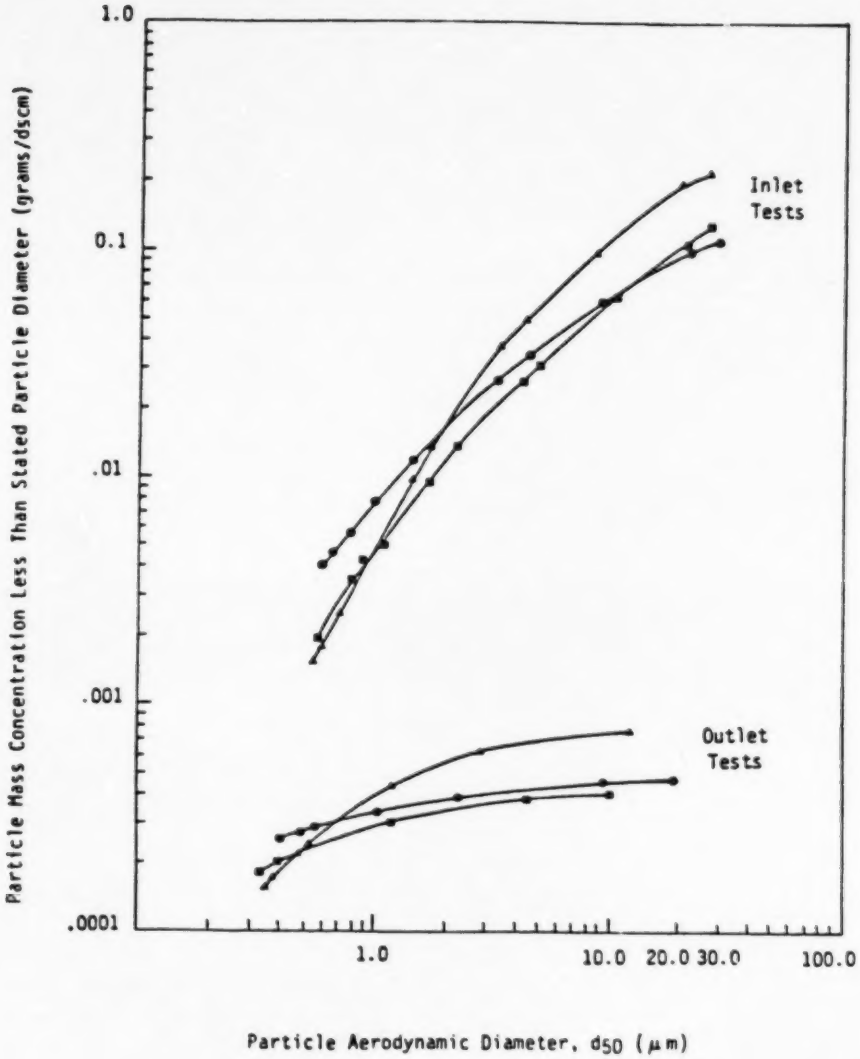

Figure 1. Typical Impactor Testing Results.

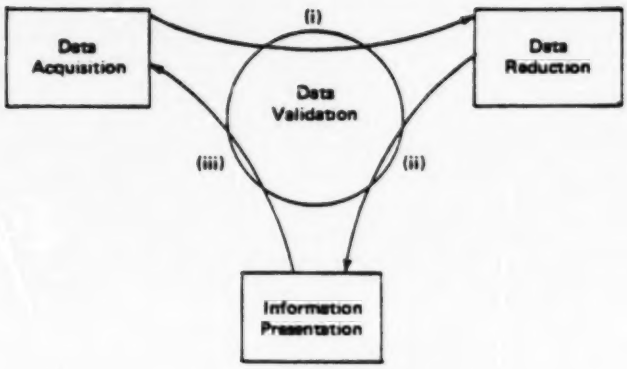

Figure 2. Idealized data flow schematic.

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 PARTICULATE DATA REDUCTION AND ENTRY SYSTEM      09/23/83          11:18:23
DATA FOR TEST BY CONTRACTOR XYZ , AT SITE RTP , ON DATE  92283. RUN NO.  1
SAMPLING AT  102.0 % OF ISOKINETIC RATE
WANT TO SEE RESULTS USING CLASSICAL (STOKES) DEF. OF DIAM.?  ENTER Y OR N
YY

PADRE presentation using data from CIDAS manual
TOTAL MASS  2.4949-002  3.5258-002  5.7092+001  8.0682+001       DMAX: 200.0
              GR/ACF       GR/DNCF      MG/ACM       MG/DNCM            MICRONS

 STAGE       MASS        MASS    CUM. MASS       D50     GEO. MEAN  DM/DLOGD   DN/DLOGD
             (MG)    (MG/DNCM)  (MG/DNCM)  (MICRONS)  (MICRONS)  (MG/DNCM)  (NO/DNCM)
NOZZLE        .01         .03      80.65      30.00      77.46   4.04-002   7.09+001
     1       9.93       19.73      60.92       5.61      12.97   2.71+001   1.01+007
     2       2.61        8.68      52.24       6.33       5.96  -1.65+002  -6.37+008
     3       3.01       10.01      42.22       3.90       4.71   3.89+001   3.04+008
     4       5.81       19.33      22.89       1.43       2.24   4.97+001   3.63+009
     5       4.01       13.34       9.55  -     .69        .99   4.18+001   3.32+010
     6       1.80        5.99       3.56       .36        .50   2.14+001   1.43+011
     7        .40        1.33       2.23       .25        .30   8.44+000   2.56+011
FILTER        .67        2.23                  .18        .30   7.41+000   1.10+012
   *** CUT POINTS FOR STAGES  1  2 ARE SIMILAR OR INVERTED
       MEASURED DATA FOR STAGE.  2 WITH D50:     6.33 OMITTED FROM INTERPOLATION
INTERPOLATED TO STD. INTERVALS: (VALUES AT DIAM. MARKED WITH * ARE EXTRAPOLATED)
                                 2.71        .30                 8.46+000
                                 8.37        .63                 2.83+001
                                16.12       1.00                 4.19+001
                                20.29       1.25                 4.40+001
                                32.48       2.50                 5.65+001
                                62.07       5.00                 4.43+001
                                69.81      10.00                 3.10+001
                                74.73      15.00                 2.49+001
                                77.37      20.00                 2.09+001
```

Figure 3. PADRE reduced data terminal output.